

ESTIMATING REBOUND EFFECTS FROM TECHNICAL ENERGY EFFICIENCY IMPROVEMENTS BY UK HOUSEHOLDS

Mona Chitnis, University of Surrey, Tel. +44 (0) 1483 682181, Email: m.chitnis@surrey.ac.uk
Steve Sorrell, University of Sussex, Tel. +44 (0) 1273 877067, Email: s.r.sorrell@sussex.ac.uk
Angela Druckman, University of Surrey, Tel. +44 (0) 1483 686671, Email : a.druckman@surrey.ac.uk
Tim Jackson, University of Surrey, Tel. +44 (0) 689072, Email : t.jackson@surrey.ac.uk

Overview

Both technical improvements in energy efficiency and behavioural change by households are expected to play a key role in the UK's attempts to meet its carbon reduction targets. However, UK policy-makers are increasingly aware that the energy and carbon savings predicted by simple engineering calculations are generally not realised in practice. This is because such changes can have unintended consequences. For example, cavity wall insulation makes heating cheaper, hence encouraging households to heat their home for longer or to higher temperatures. Any savings in heating costs may be spent on other goods and services, the provision of which consumes energy and produces carbon emissions. This problem of 'rebound effects' is widely neglected, in part because such effects are difficult to quantify. However, these effects invariably offset and in some cases entirely eliminate the environmental benefits from both technical and behavioural change.

Policy-makers face two problems: (a) empirical evidence on the magnitude of such effects is extremely limited, especially for the UK; (b) even if policy-makers were to have better information, they struggle to understand how best to deal with it.

This paper addresses both these problems. We first illustrate the nature and origin of both 'direct' and 'indirect' rebound effects for households, identify key factors determining the magnitude and sign of these effects and highlight the difficulties of empirical estimation. Second, we estimate the magnitude of such effects for a number of energy efficiency actions i.e. cavity wall insulation, tank insulation top up and LED light bulbs. Our empirical work uses estimates of expenditure elasticities for 16 categories of household consumption and a household savings category, derived from a Structural Time Series Model (STSM) of household consumption. These are combined with GHG intensities derived from an environmentally extended input-output model. The conclusion considers ways in which such effects may be reduced, where necessary, and implications for UK climate policy.

The paper is organised as follows. After the introduction and background in first and second sections, the third section introduces the empirical methodology and assumptions that are used to estimate the rebound effect. The results are given in section four and a summary and conclusion in section five.

Methods

Three energy efficiency improvement measures that an average UK household may take to reduce energy expenditure and emissions are considered. The expected (hoped for) annual reduction in GHG emissions (ΔH), and approximate annual expenditures (Δy) that are likely to be avoided are given by UK government. We assume that the latter are either re-spent on goods and services or saved (invested). This leads to additional GHG emissions (ΔG) that offset some or all of the anticipated GHG savings (ΔH). The rebound effect is defined as $\frac{\Delta G}{\Delta H}$.

Rebound estimation above relies on having information on the GHG intensity of different categories of goods and services, and the expenditure elasticities of those goods and services. In this study we make use of two models developed within RESOLVE (Research group on Lifestyles, Values and Environment) at the University of Surrey: a) Surrey Environmental Lifestyle Mapping (SELMA) framework from which we obtain GHG intensities and b) Econometric Lifestyle Environmental Scenario Analysis (ELESA) model from which we obtain estimates of income elasticities (using econometric approach of STSM) and future GHG emissions. Using relevant equations, the rebound effect is derived as follow:

$$Rebound = \frac{1}{\Delta H} \left\{ \left[\frac{(1-r)\Delta y}{\sum_{i=1}^{16} \beta_i \exp_i} \right] \sum_{i=1}^{16} \beta_i \exp_i u_i + u_i c_i + r u_s \Delta y - u_s c \right\}$$

where:

Δy is the expenditure avoided by the energy efficiency improvement measure.

r is the savings ratio, defined here as the ratio of disposable income y that is put into savings. The expected savings ratio r is estimated through ELESa.

exp_i is expenditure in category i . This is predicted from ELESa.

u_i and u_s are GHG intensities in expenditure category i and saving (investment) respectively. These are estimated using ELESa and SELMA.

β_i is the income elasticity of expenditure. This is estimated using ELESa.

c_i is the cost of energy efficiency measure for category i .

c is the total cost of energy efficiency measures.

The rebound effect is estimated under two different assumptions regarding household payable cost of the measures after government grant: a) full cost of the measures is covered by households' savings in the first year (2011) and b) cost of the measures is covered by loan. The rebound is estimated for each of the three energy efficiency improvement measures either one at a time or in combination.

Results

Preliminary results find that under conditions of 'behaviour as usual', when cost of energy efficiency measures is covered from household saving, the estimated rebound effect when all three measures are applied is around 6% in 2011 (when the measures are applied) and on average around 4% for 2012 to 2050 (lifetime of measures). When cost of energy efficiency measures is covered by loan then the estimated rebound effect for all three measures is about 6% during the loan period (2011-2015) and about 3% after loan period and until 2050. This means that almost the anticipated GHG emissions reductions are likely to be achieved.

Conclusions

In conclusion, this study suggests that the rebound effect is almost negligible in case of three energy efficiency measures applied by households. Therefore, in order to reduce emissions, encouraging households to apply energy efficiency improvements at homes, without any other policy to compensate for rebound effect, is fine. However, this is not always the case. For example, in our earlier study (Druckman et al 2010), results demonstrated that some green actions have a much more significant rebound of around 34% for GHGs. In general, therefore, we conclude that the rebound effect varies widely according to the actions taken, depending largely on the cost of the energy efficiency measure. If high rebound effects are ignored and no steps are taken to reduce them, achieving emission targets will become even more of a Sisyphean task than it already seems.

References

- Chitnis, M. and L. C. Hunt (2010): "Modelling UK household expenditure: economic versus non-economic drivers." *Applied Economics Letters*, in press.
- Chitnis, M., A. Druckman, L. Hunt, S. Milne and T. Jackson (2009): "Analysing the Role of Lifestyles in Determining UK Household Energy Demand and GHG Emissions: Predictions and Scenarios to 2050." Conference on Energy Economics and Technology. Long-term Energy Trends – Where will we be in 2050?, Dresden, Germany.
- Druckman, A., M. Chitnis, S. Sorrell and T. Jackson (2010): "Shifting sands? Exploring rebound and backfire in a changing economy." International Society for Ecological Economics (ISEE) 11th Biennial Conference: Advancing sustainability in a time of crisis, Oldenburg and Bremen, Germany.
- Druckman, A. and T. Jackson (2009): "The carbon footprint of UK households 1990-2004: a socio-economically disaggregated, quasi-multiregional input-output model." *Ecological Economics* 68 (7): 2066–2077.
- Sorrell, S., J. Dimitropoulos and M. Sommerville (2009). "Empirical estimates of the direct rebound effect: A review." *Energy Policy* 37(4): 1356-1371.
- Sorrell, S. (2010): "Mapping rebound effects from sustainable behaviours: key concepts and literature review." Brighton, Sussex Energy Group, SPRU, University of Sussex.